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Description

[ELECTROPLATING APPARATUS]

BACKGROUND OF INVENTION

[0001] Field of the invention: The present invention generally pertains to an electroplating apparatus, and more particularly to an electroplating apparatus equipped with a flow distribution device to improve an electroplating result.

[0002] Description of the Related Art:As integration of an integrated circuit (IC) increases, the surface area of the IC is no longer sufficient forming wiring in the high density IC. As a transistor made of a metal oxide semiconductor gets smaller, increased number of wiring within a given surface area is necessary, a Multilevel Metallization Process (MMP) is more commonly used in an IC fabrication.

[0003] In the MMP, a contact opening or a dielectric opening is first etched out, the contact opening or a dielectric opening is then filled in with a metal to form a contact plug or a via plug. Next, a metal wire is formed to connect to the contact plug or the via plug. Generally, a physical vapor deposition (PVD), a chemical vapor deposition (CVD) or an

electroplating method is commonly used to grow a metal layer. In these methods, costs of the PVD and the CVD are higher than that of the electroplating, and a defect in gap-filling which commonly observed with PVD and CVD methods also degrades a conductivity of a wiring. Additionally, a requirement of a clean room for the electroplating is not as high as a requirement of a clean room for the PVD or the CVD. Therefore, using the electroplating to grow a metal wire is a better choice to form a metal layer in an IC fabrication.

[0004] Referring to Fig. 1, a sectional view of a commonly used electroplating apparatus is depicted. The electroplating apparatus 100 is used to electroplate a wafer 102. The wafer 102 has an active surface 102a and a back side 102b. The active surface 102a comprises an electroplating area 102c at a center of the active surface 102a and at least an electrical contact point 102d at a rim of the active surface 102a. The electroplating area 102c comprises a plurality of via holes (not shown in figures). The electroplating apparatus 100 comprises an outer bath 104, an inner bath 106, a meshed anode electrode 108, a cathode electrode 110 and a plating solution supply device 112. The inner bath 106 is funnel shaped and is placed with a

bigger-opening end faced down inside the outer bath 104. The bigger-opening of the inner bath 106 is smaller than the outer bath 104. The meshed anode electrode 108 is placed inside the inner bath 106. The cathode electrode 110 is placed at a bottom of the outer bath 104, and is electrically connected to the contact point 102d of the wafer 102. The cathode electrode 110 couples the wafer 102a and the outer bath 104 closely to prevent plating solution from leaking. The plating solution supply device 112 pumps plating solution to the inner bath 106 through a smaller-opening of the inner bath 106. Next, plating solution flows from the inner bath 106 to the outer bath 104 to fill up the outer bath 104 via a gap between the inner bath 106 and the outer bath 104. Then, plating solution recycles back to the plating solution supply device 112 to complete a flow cycle, and thereby, the plating solution in the inner bath 106 and outer bath 104 is renewed.

[0005] As an integration of an IC increases, a size of a circuit element continue to reduce and a size of a via hole on a wafer also correspondingly continue to get smaller. In the conventional electroplating process, because the apparatus does not include any means for distributing the flow

and flow pressure of the plating solution and therefore uneven plating of the metal layer on the wafer, causing undesirable defects, such as, metal layer not filling up a via hole completely, or metal partially filling up a via hole.

SUMMARY OF INVENTION

[0006] Accordingly, in the light of the above problems of the prior art, it is an object of the present invention to provide an electroplating apparatus that is capable of adjusting the distribution of plating solution on a wafer for allowing a metal layer to be uniformly plated on the wafer so that a via can be completely filled with the metal layer.

[0007] In accordance with the above objects, the present invention provides an electroplating apparatus. The electroplating apparatus comprises a bath in which a workpiece is placed and secured. A meshed anode electrode is placed in the bath, a cathode electrode placed at a bottom of the bath and electrically connected to the electric contact point at a rim of the workpiece. A flow-distribution device is placed between the meshed anode electrode and the workpiece. The flow-distribution device comprises a plurality of holes, and through these holes, the plating solution is uniformly distributed on the workpiece.

[0008] Preferably, the flow-distribution device is comprised of an

insulating material. The holes of the flow-distribution device are evenly distributed on the flow-distribution device. The shape of the hole can be conical or cylindrical H-shape.

[0009] The bath is equipped with a plating solution inlet and at least a plating solution outlet. The plating solution flows into the bath through the inlet and flows through the meshed anode electrode, then through the flow-distribution device for uniformly distributing the flow of the plating solution over the workpiece. Thereafter, the plating solution flows out of the bath via the plating solution outlet, and a fresh plating solution charged into the bath through the inlet again to complete a flow cycle.

[0010] The above bath may be comprised an outer bath and an inner bath. A workpiece interface is designed in the outer bath. The inner bath is placed within the outer bath. A flow-distribution device is placed within the inner bath and positioned to flow the plating solution towards the workpiece interface where a workpiece is secured. The outer bath is equipped with a plating solution outlet and the inner bath is equipped with a plating solution inlet. The plating solution flows from the plating solution inlet into the inner bath and flows through the meshed anode

electrode and through the flow-distribution device to uniformly distribute the flow and the flow pressure of the plating solution over the workpiece interface area, and then exits the bath via the plating solution outlet of the outer bath and fresh plating solution charged into the bath through the plating solution inlet. Thus the plating solution is refreshed.

[0011] The electroplating apparatus of the present invention provides a flow-distribution device in a plating bath for allowing even flow and flow pressure of the plating solution over the workpiece so that the plating solution can be uniformly distributed over the surface of the workpiece. Therefore a metal layer can uniformly grown on the workpiece.

Brief Description of Drawings

[0012] The accompanying drawings are included to provide a further understanding of the invention, and are incorporated by reference constituting a part of this specification. The drawings illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention. The drawings are as follows.

[0013] Fig. 1 illustrates an electroplating apparatus of a prior art.

[0014] Fig. 2 depicts an electroplating apparatus according to a preferred embodiment of the present invention.

[0015] Fig. 3 depicts an inner bath of the electroplating apparatus according to the preferred embodiment of the present invention.

[0016] Fig. 4A depicts a top view of a flow-distribution device of the electroplating apparatus of the preferred embodiment of the present invention.

[0017] Fig. 4B depicts a sectional view of a flow-distribution device of the electroplating apparatus according to the preferred embodiment of the present invention.

[0018] Fig. 4C depicts a section view of a flow-distribution device of the electroplating apparatus according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION

[0019] A sectional view of an electroplating apparatus according to a preferred embodiment of the present invention is depicted in Fig. 2. A perspective drawing of an inner bath of the electroplating apparatus according to the preferred embodiment of the invention is depicted in Fig. 3.

[0020] Referring to Fig. 2 and Fig. 3, the electroplating apparatus 200 of the present invention comprises a bath 201, a meshed anode electrode 206, a flow-distribution device

208, a cathode electrode 210, and a plating solution supply device 212.

[0021] The bath 201, for instance, comprises an outer bath 202, and an inner bath 204. The outer bath 202, for instance, is equipped with a workpiece interface 202a where a to-be-plated workpiece can be placed. The workpiece interface 202a, for instance, is designed to electroplate a wafer 214. As the wafer 214 is placed under the workpiece interface 202a, a sealing device (not shown in the figures) couples the wafer 214 and the outer bath 202 tightly together such that the wafer 214 completely seals the bottom of the outer bath 202 so that the plating solution is trappedwithin the outer bath 202. The wafer 214 comprises an active area 214a and an inactive area 214b. The active area 214a comprises a plating area 214c at a center of the active area 214a, and at least an electrical contact point 214d at a rim of the active area 214a. A plurality of via holes (not shown in the figures), for instance, is formed on the plating area 214c. The inner bath 204, for instance, is funnel shaped, and is placed upside down in the outer bath 202. In other words, a bigger opening 204a of the inner bath 204 is placed facing down, and a smaller opening 204b of the inner bath 204 (where the plating

solution flows in) is placed facing up. The bigger opening 204a of the inner bath 204 is smaller than the outer bath 202, and a space between the bigger opening 204a and the workpiece interface 202a of the outer bath 202 is provided.

[0022] The meshed anode electrode 206, for instance, is placed inside the inner bath 204, and a space between the meshed anode electrode 206 and the bigger opening 204a is provided.

[0023] The flow-distribution device 208, for instance, is placed between the meshed anode electrode 206 and the wafer 214. For example, the flow-distribution device 208 is placed above the bigger opening 204a of the inner bath 204. The flow-distribution device 208 is equipped with a plurality of flow-distributing holes. Fig. 4A, Fig. 4B, and Fig, 4C illustrate the flow-distributing holes 208a of the flow-distribution device 208 according to the preferred embodiment of the present invention. A top view of the flow-distribution device 208 is depicted in Fig. 4A. Respectively, Fig. 4B and Fig. 4C depict sectional views of the flow-distributing holes of the flow-distribution device 208 of the present invention in various shapes. Referring to Fig. 4A, the flow-distributing holes 208a are dis-

tributed evenly on the flow-distribution device 208 in which a space interval between two holes 208a along a row is at Y distance and a space interval between two holes 208a in adjacent rows is at Z distance. Further, referring to Fig. 4B, a shape of the flow-distributing holes 208a, for instance, is conical. A section view of the conical hole is shown as an isosceles trapezoid. Preferably, the smaller opening of the conical hole is positioned towards the plating area 214c of the wafer 214. Another preferred shape of the flow-distributing hole 208a is a cylindrical H-shape as depicted in Fig. 4C. For example, the cylindrical H-shaped hole can be forming using a conventional drilling method. Preferably, the cylindrical H-shaped hole has a differential diameter as depicted in FIG. 4. A distance between the flow-distribution device 208 and the wafer 214, for instance, is 0.1 millimeter (mm) to 500 mm.

[0024] The cathode electrode 210, for instance, is placed laterally adjacent to the workpiece interface 202a within outer bath 202, and is electrically connected to the electrical contact point of the wafer 214. Thus, the cathode electrode 210 is electrically coupled to the wafer 214.

[0025] The plating solution supply device 212 pumps the plating

solution into the inner bath 204 via the opening 204b of the inner bath 204. The plating solution flows through the flow-distribution device 206 via the space between the inner bath 204 and the outer bath 202 to the outer bath 202, and fills up the outer bath 202. Then, the plating solution flows back to the plating solution supply device 212 via the plating solution outlet 202b to complete a flow cycle, and then the plating solution in the inner bath 204 and the outer bath 202 is refreshed.

[0026] The electroplating apparatus according to the preferred embodiment of the present invention is illustrated above. Next, an electroplating process using the electroplating apparatus is illustrated as follows.

[0027] Referring to Fig. 2, a wafer 214 is placed under the workpiece interface 202a of the outer bath 202, and the cathode electrode 210 is electrically connected to an electrical contact point 214d of the wafer 214. The sealing device (not shown in the figures) couples the wafer 214 and the outer bath 202 tightly together so that the wafer 214 forms the bottom plate of the outer bath 202 and traps the plating solution within the outer bath 202. Then, the plating solution supply device 212 pumps the plating solution into the inner bath 204 via the plating solution inlet

204b. The plating solution flows through the flow-distributing holes 208a of the flow-distribution device 208 to the outer bath 202. The flow-distributing holes 208a are designed to provide an even distribution of the plating solution together with even flow and flow pressure of the plating solution over the wafer 214 so that the plating solution uniformly reaches each via hole on the wafer 214. The plating solution fills up the outer bath 202 gradually via the space between the inner bath 204 and the outer bath 202. Then, the plating solution flows back to the plating solution supply device 212 via the plating solution outlet 202b, and the plating solution in the inner bath 204 and the outer bath 202 is refreshed accordingly. Next, a power supply is connected to the meshed anode electrode and the cathode electrode to start the electroplating process. During the electroplating process, the plating solution constantly washes over the wafer 214 with an uniformly distributed fluid flow pressure. A metal is grown uniformly in each via hole on the wafer 214, and therefore partially filled via hole contributed to uneven flow of the plating solution can be effectively avoided.

[0028] In the preferred embodiment mentioned above, the electroplating bath 201 is equipped with the flow-distribution

device 208 for uniformly distributing the plating solution with even flow pressure over the wafer 214, and therefore the plating solution can be constantly maintained on the wafer 214 so that the plating solution can reach each and every via holes during the electroplating process.

[0029] Moreover, because of the flow-distributing holes 208a of the flow-distribution device 208, a perturbation motion of the plating solution on the wafer 214 is increased, and this compensates an effect of non-uniform distributed fluid flow and pressure. Therefore, a metal lay is uniformly grown on the wafer 214, and therefore the phenomena of non-uniformly formed metal layer and a partially filled via holes can be effectively avoided.

[0030] Further, in the preferred embodiment of the present invention mentioned above, the flow-distribution device 208 is placed within the bigger opening of the inner bath 204. However, the flow-distribution device 208 and the inner bath 204 can be integrally formed as a single device to make the flow-distribution device 208 as an integral part of the inner bath 204.

[0031] In the preferred embodiment of the present invention, the electroplating bath 201 consists of the outer bath 202 and the inner bath 204. However, the flow-distribution device

208 may also be integrated in a single electroplating bath to practice the present invention. As a result, a metal can be uniformly grown in each via hole on the wafer 214, and a metal layer can be uniformly formed on the wafer 214. Therefore, non-uniformly formed metal layer and partially filled via hole can be effectively avoided.

[0032] It will be apparent to those skilled in the art that various modifications and variations can be made to the structure or to the methods of the preferred embodiment of the present invention without departing from the scope or spirit of the invention. In view of the foregoing, it is intended that the present invention cover modifications and variations of this invention provided they fall within the scope of the following claims and their equivalents.